Computer Methods of Analysis of Offshore Structures
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Module - 02
Lecture - 13
Dynamic Analysis - 2 (Part - 1)

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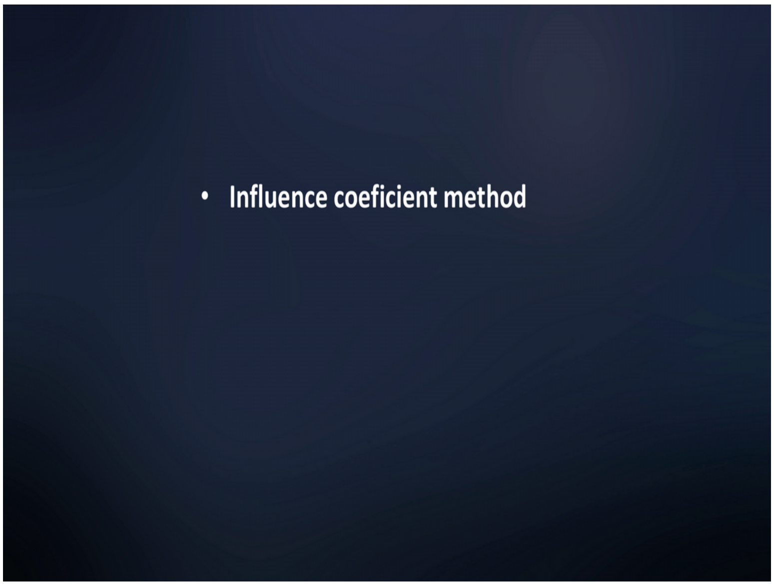

Friends let us continue with the 13th lecture on module 2 where we will continue to discuss dynamic analysis to obtain natural frequencies and mode shapes of a dynamic system. In the last lecture we discussed the first method which is the classical eigen solver method to obtain natural frequency and the corresponding mode shape for an mdof system.

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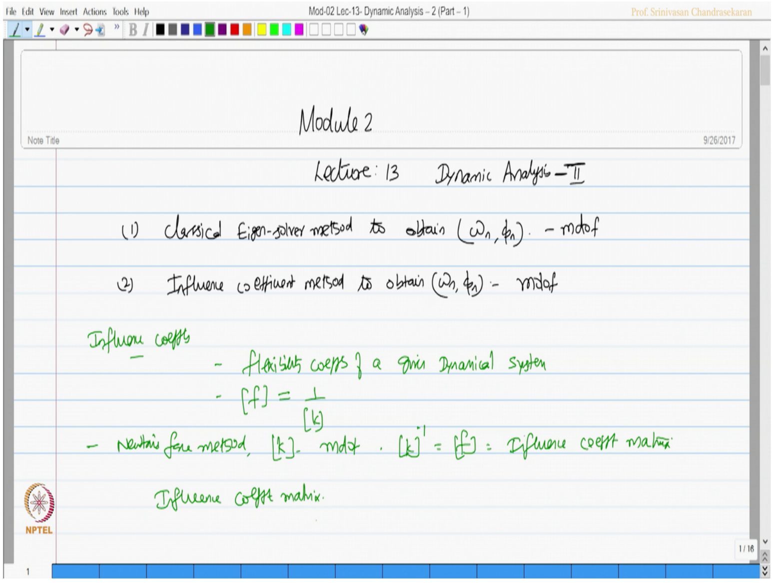

In this lecture we will discuss about another numerical method which is influence coefficient method to obtain natural frequency and mode shape. For your multi degree freedom system model what are the influence coefficients. Influence coefficients are nothing but flexibility coefficients of a given system if flexibility is expressed as small f it has relationship with stiffness for a given system using Newton's force method we can derive stiffness matrix for an mdof system. So, just take an inverse of the stiffness matrix it will actually give you the flexibility which is influence coefficient matrix.

But in this lecture we will explain you how to obtain the influence coefficient matrix directly without inverting the stiffness matrix.

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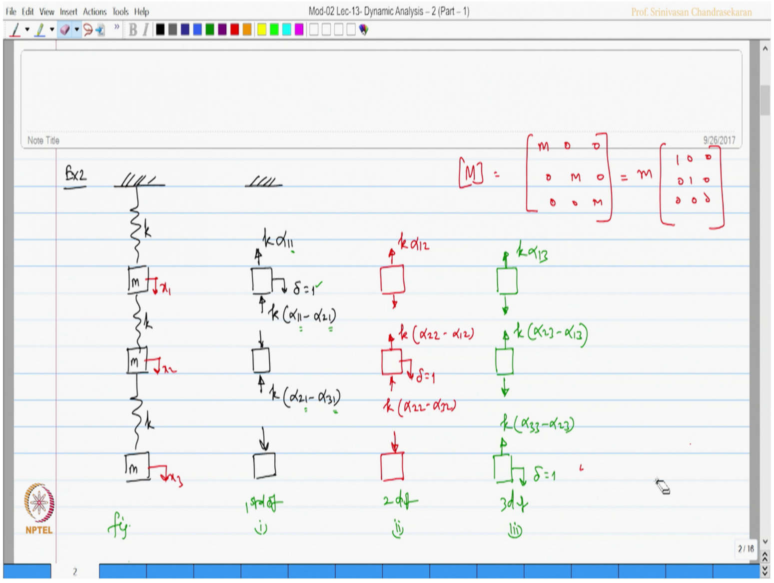

So, we will take an example of a three degree freedom system model mass being all equal and stiffness being all the equal here, the degrees of freedom are marked as x 1 x 2 and x three. So, flexibility is to give unit deflection and find the force. So, let us say I want to draw the first degree, so the unit deflection and find the force. So, this is going to be k times of alpha 11 whereas, this spring will oppose is going to be k times of alpha 11 minus 21. We will have the same value, but opposite in direction this bottom spring will oppose k times of alpha 21 minus 31. So, this spring we will have an opposite direction of the same value.

So, you must realize that the second subscript in this derivation is all 1 meaning that we are giving unit displacement and the first degree. Similarly I can do for the second degree. So, I give delta as unity here. So, in that case this spring will have a force which will offer alpha 22 minus 12 this will be opposite and this will be stiffness of alpha 12 and this will be stiffness of alpha 22 minus 32 this will be opposite.

Similarly, we can do for the third degree that delta v unity. So, this will be k times of alpha 33 minus 23 this is opposite. This will be k times of alpha 23 minus 13 and this will be opposite and this will be k times alpha 13. So, this is first degree, this is second degree, this is third degree.

So, let me write down the equations based on this let us take the first figure that is this is the master figure this is figure 1 this is figure 2 this is figure 3. Let us take figure 1. So, figure 1 was unity here and this was k alpha 11 and this was k alpha 11 minus 21 and this was k alpha 21 minus 31.

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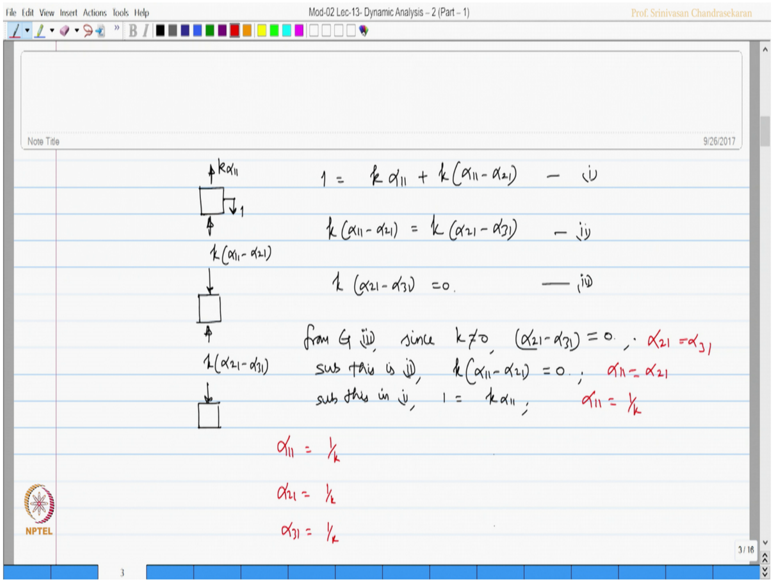

So, let us write down the equilibrium equation 1 which is acting downward should be equal to k alpha 11 plus k alpha 11 minus 21. Similarly I can also write k alpha 11 minus 21 is k alpha 21 minus 31 I can also write k alpha 21 minus 31 is 0 this equation 1 equation 2 and equation 3. So, from equation three since k cannot be equal to 0 alpha 21 minus alpha 31 is said to 0 which implies that alpha 21 is equal to alpha 31. Now substituting this in 2 we get k of alpha 11 minus 21 is 0 which implies that alpha 11 is also equal to alpha 21 substituting this further in 1 we get 1 equals k alpha 11 which implies that alpha 11 is 1 by k.

So, now I get alpha 11 is 1 by k, alpha 21 is also 1 by k and alpha 31 is 1 by k I get the first column of my influence coefficient matrix. Let us move on to the second figure.

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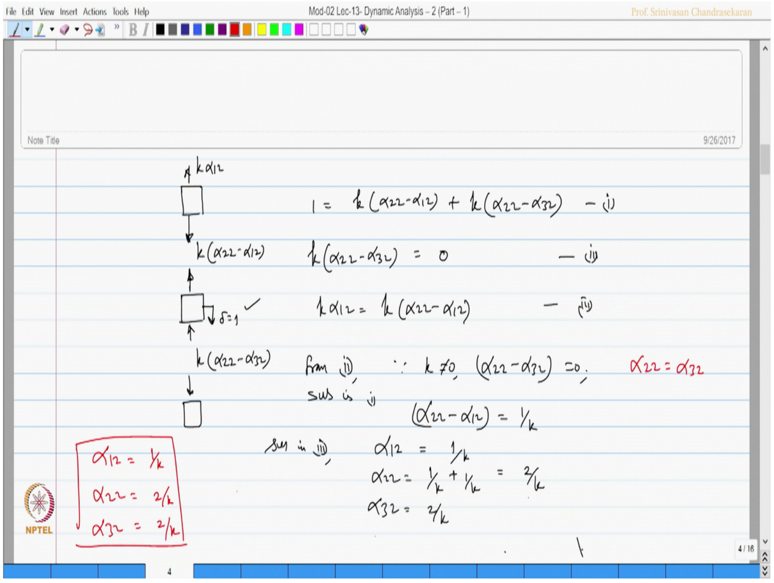

The second figure was indicating like this delta equals unity here which implies k times of alpha 22 minus 12 k times of alpha 12 and k times of alpha 22 minus 32 writing the equation 1 we will be equal to for this k times of alpha 22 minus 12 plus k times of alpha 22 minus 32. And the second equation says k times of alpha 22 minus 12 is 0, then we say k times of alpha 12 is k times of alpha 22 minus alpha 1. Call this as equation number 1, 2 and 3.

So, from 2 since k cannot be 0 alpha 22 minus 12 is 0 which implies alpha 22 is equal to k times of alpha 22 minus 32 is 0 which indicates alpha 22 minus alpha 32 is 0 we says that alpha 22 is actually equal to alpha 32 n 1 we say that alpha 22 alpha 22 minus alpha 12 is actually equal to 1 by k. So, substituting this in 3 alpha 22 minus 1 21 by k, so alpha 12 is actually equal to 1. So, therefore, alpha 22 is 1 by k plus alpha 1 21 by k plus 1 by k which is 2 by k and alpha 32 is also equal to 2 by k.

So, now this gives in the second column alpha 12 alpha 22 alpha 32 alpha 12 is 1 by k alpha 22 is 2 by k and this is also 2 by k. So, that is my second column of my influence coefficient matrix.

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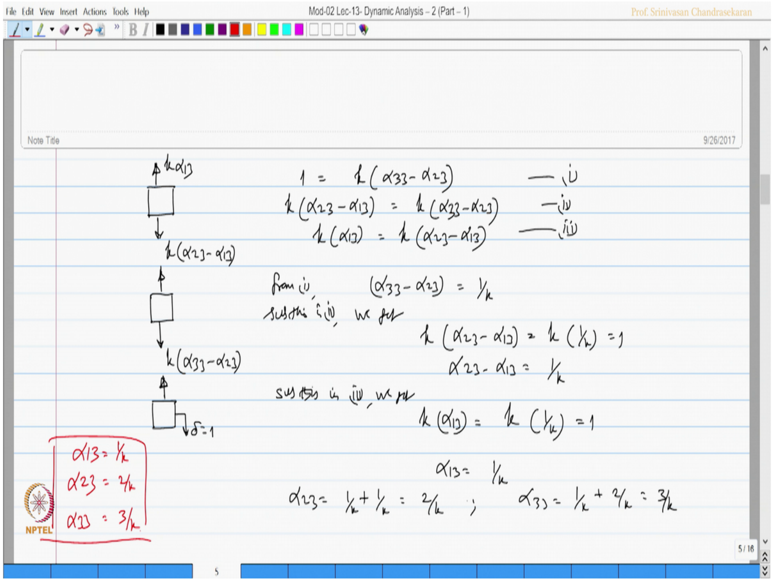

Let us do the third figure. So, delta as unity here, this implies k times of alpha 33 minus 23 which implies k times of alpha 23 minus 13 this is alpha 13.

So, writing the equations of equilibrium 1 is equal to k times of alpha 33 minus 23 and k times of alpha 23 minus 13 is k times of alpha 33 minus 23, k times of alpha 13 will be k times of alpha 23 minus 13 equation 1, 2 and 3. So, from 1 it says that alpha 33 minus 23 is 1 by k substituting this in 2 we get k of alpha 23 minus 13 is equal to k times of 1 by k which is 1 which implies alpha 23 minus 13 is also equal to 1 by k. Substituting this in 3, we get k times of alpha 13 is k times of 1 by k which means 1 solve for 13 is 1 by k. So, alpha 23 is 1 by k plus 1 by k which is 2 by k and alpha 33 is 1 by k plus 2 by k which is 3 by k. So, now, I get alpha 13 alpha 23 alpha 33 as 1 over k 2 over k and 3 over k. I get the third column of the influence coefficient matrix.

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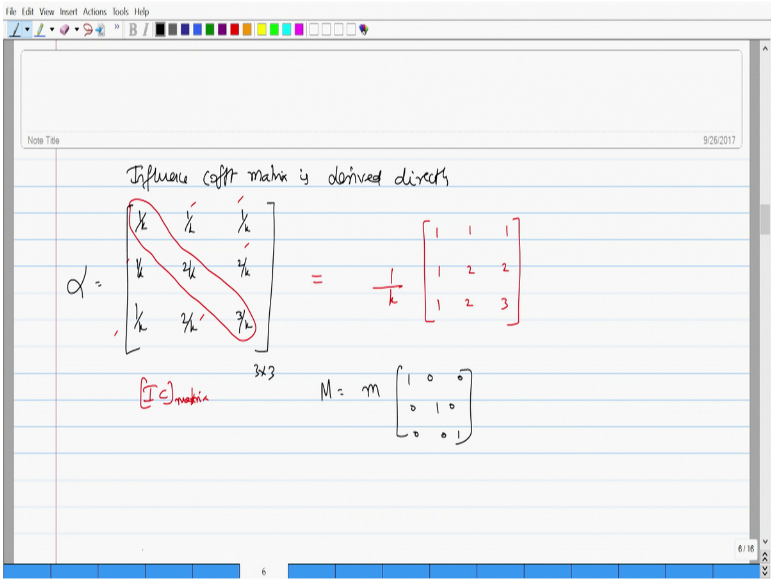

So, the influence coefficient matrix is derived directly as explained and the matrix which I call as alpha matrix is a 3 by 3 matrix 1 over k, 1 over k, 1 over k, 1 over k, 2 over k, 2 over k, 1 over k, 2 over k, 3 over k. So, this is symmetric diagonally dominant and square. So, this is the influence coefficient matrix is directly direct. Once a derive this I can also write this matrix as 1 by k of 1 1 1, 1 2 2, 1 2 and 3. For the given problem if we write the mass matrix from this figure it is easily m 0 0, 0 m 0, 0 0 m which can be also said as m times of 1 0 0, 0 1 0, 0 0 0. So, now, I have alpha matrix I have mass matrix which is m times of 1 0 0, 0 1 0, 0 0 1.